Continuing Research Proposal

EVALUATION OF ADULT SALMON AND STEELHEAD MIGRATIONS PAST DAMS, THROUGH RESERVOIRS, AND INTO TRIBUTARIES IN THE LOWER COLUMBIA RIVER - 2005

for

U. S. Army Corps of Engineers - Portland District

Study Codes: ADS-00-1, ADS-00-4, ADS-00-13

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Project Summary

A. Goals

This study plan contains objectives and procedures for the adult salmon and steelhead portion of the Adult Fish Passage Project for the Lower Columbia River that are funded by the Portland District, U.S. Army Corps of Engineers (CORPS). The goals of this project include 1) monitoring the passage of adult salmon and steelhead at lower Columbia River dams, through their reservoirs, and into tributaries, 2) investigating fish responses to flow, spill, dam operations and river conditions, 3) assessing cumulative effects of passage times and behavioral responses on escapement and reproductive success, and 4) evaluating measures to improve passage. Activities proposed for 2005 primarily involve analyses and reporting of results from data collected in previous field seasons.

B. Primary Objectives – Year 2005

1. Summarize existing data (1996-2004) on fallback and effects of fallback on passage success for adult salmon and steelhead at lower Columbia River dams, in relation to environmental and operational conditions (ADS-00-1).

2. Summarize existing data (1996-2004) on behavior, passage times, and effects of passage times on passage success of adult salmon and steelhead at lower Columbia River dams in relation to environmental and operational conditions (ADS-00-1).

3. Develop evolutionarily significant unit (ESU)-based models and evaluate alternative methodologies (e.g., PIT tag technology) that can be used to estimate adult fallback and passage behaviors without radiotelemetry (ADS-00-1).

4. Identify index stocks (e.g., South Fork Salmon River) to PIT tag and index streams to monitor to estimate adult passage parameters (ADS-00-1 and ADS-00-13).

5. Summarize existing data (2000-2004) on homing and straying of known-source (PIT-tagged) adult salmon and steelhead (ADS-00-4).

6. Evaluate use of existing telemetry information for known-source fish to develop methods to estimate straying rates for ESUs (or ESU surrogates) in years without radiotelemetry (ADS-00-4).

7. Assess the effects of passage through the Columbia-Snake hydrosystem on the survival and reproductive fitness of adult salmon and steelhead (ADS-00-13).

8. Evaluate detection efficiencies of new vertical-slot PIT tag detectors at the top of the Washington-shore ladder, Bonneville Dam.

9. Maintain and perform quality control on the existing web-based interface to radiotelemetry data and broaden its scope to include additional years of data.

C. Methods

In 2005, we propose to summarize in final reports radiotelemetry data collected from 1996 through 2004 that address research actions outlined in the 2000 Biological Opinion (BIOP) developed by NOAA Fisheries (previously National Marine Fisheries Service [NMFS]). Specific summary topics include fallback, passage times, fish behavior at dams, homing and straying, escapement, and reproductive fitness and success. In addition, we propose to continue development of predictive models that can be used for evaluating adult salmon and steelhead behaviors in the absence of radiotelemetry. Modeling efforts will focus on use of the radiotelemetry databases and on emerging PIT-tag technologies, with particular emphasis on ESU-level assessments.

D. Relevance

The studies proposed herein address priority research areas related to improving passage and survival of adult salmonids identified by the Corps of Engineers, fish agencies, and NOAA Fisheries in the Columbia River Federal Power System Biological Opinion released in 2000 related to recovery of threatened and endangered Columbia and Snake River salmon and steelhead. Specific RPAs identified in the NMFS Biological Opinion will be noted by objective.

Project Description

A. Background

Adult salmon and steelhead migrating to their natal streams in tributaries of the Columbia River must pass up to nine dams and their reservoirs, four each in the lower Columbia and Snake rivers and five in the mid Columbia River. Stress, delays, and losses during migration at each hydroelectric project and associated reservoir must be minimized to succeed in maintaining the native runs of fish and to achieve the recovery goals outlined by the Northwest Power Planning Council (NWPPC) and by the NOAA Fisheries.

This proposal was developed in response to requests for preliminary proposals issued by the U.S. Army Corps of Engineers (CORPS) in July 2004, and addresses concerns of the CORPS, the NWPPC in the Columbia River Basin Fish and Wildlife Program, and by NMFS in the Proposed Recovery Plan for Snake River Salmon, and Biological Opinion issued in 2000 (which supercedes the 1995 and 1998 Biological Opinions). The proposal has been developed in consultation with personnel from the CORPS.

Research activities proposed for 2005 are a continuation of studies of adult salmon and steelhead passage at Columbia River dams conducted in recent years to evaluate passage and survival through the hydrosystem and develop means to increase passage efficiency. In previous years (1996-2004), fish were trapped at Bonneville Dam, outfitted with radio transmitters, and monitored at dams, in reservoirs, and in tributary streams. Collected radiotelemetry data have been used to better define: (1) the use of fishway entrances and passage through the fishways, (2) the effect of spill and powerhouse discharge patterns on the entry of fish into the fishways and on passage rates, (3) the effects of the structural modifications, such as spill deflectors, guidance walls, and fishway entrance closures on fish passage, (4) the rate of fallback over the dams with various flow conditions, and (5) the distribution, migration rates, migration behaviors, and final fates of fish after they were tagged and released. We incorporated new technologies, such as archival and acoustic transmitters, as they became available in order to better evaluate specific questions regarding upstream migration.

In recent years, studies at Bonneville, The Dalles, and John Day dams were conducted to determine the relationship between spill and fallback rates, effects of closure of orifice gates, temperature exposure of salmon and steelhead during their upstream migration, passage success at the dams, migration rates, and factors that affect loss and escapement rates through the hydropower system and to natal streams. In 2002, we initiated a supplemental study to more closely assess reproductive success of adult migrants and develop a method to determine energy expenditures of upstream migrating adult Chinook salmon. In 2005, we propose to summarize in final reports the large radiotelemetry and archival datasets collected in previous years. Final reports will refine understanding of the many inter-related relationships between passage times, fallback, hydrosystem escapement, homing and straying, reproductive success, dam operations, and environmental conditions. Additional emphasis will be placed on developing predictive models and alternative methodologies for evaluating adult passage and survival in the absence of radiotelemetry studies.

B. Specific Objectives for 2004:

1. Summarize existing data (1996-2004) on fallback and effects of fallback on passage success for adult salmon and steelhead at lower Columbia River dams, in relation to environmental and operational conditions (ADS-00-1).

    a. Summarize fallback rates, routes, timing, and percent of fish that fall back at Bonneville, The Dalles and John Day dams in 1996-2004.

    b. Summarize multi-year (1996-2004) relationships between fallback behavior and river and operational variables.

    c. Summarize effects of fallback behaviors on hydrosystem escapement in 1996-2004.

    d. Report effects of fallback history on proportion of fish of known origin (PIT tags) that reach streams or hatcheries of origin.

2. Summarize existing data (1996-2004) on behavior, passage times, and effects of passage times on passage success of adult salmon and steelhead at lower Columbia River dams in relation to environmental and operational conditions (ADS-00-1).

    a. Summarize passage times for adult salmon and steelhead at Bonneville, The Dalles, and John Day dams, and evaluate environmental and operational factors associated with passage times from 1996-2004.

    b. Summarize effects of passage times and behaviors at dams and in reservoirs on hydrosystem escapement from 1996-2004.

    c. Report effects on passage of adult salmon and steelhead from spill flow patterns and deflectors at Bonneville and John Day dams, the new spill wall at The Dalles Dam, the modified south ladder at John Day Dam, and orifice gate closures at John Day Dam.

3. Develop evolutionarily significant unit (ESU)-based models and evaluate alternative methodologies (e.g., PIT tag technology) that can be used to estimate adult fallback and passage behaviors without radiotelemetry (ADS-00-1).

    a. Use radiotelemetry data for known-source fish (2000-2004) and for all radio-tagged fish (1996-2004) to develop predictive fallback models for lower Columbia River dams.

    b. Integrate existing radiotelemetry and PIT-tag databases to evaluate and validate methods for using PIT tags and PIT-tag detectors as an alternative to radiotelemetry for monitoring adult salmonid behaviors and fallback at lower Columbia River dams.

4. Identify index stocks (e.g., South Fork Salmon River) to PIT tag and index streams to monitor to estimate adult passage parameters (ADS-00-1 and ADS-00-13).

5. Summarize existing data (2000-2004) on homing and straying of known-source (PIT-tagged) adult salmon and steelhead (ADS-00-4).

a. Summarize homing and incidence of straying by known-source radio-tagged salmon and steelhead from 2000-2004.

b. Report stock-specific relationships between adult straying rates and rearing history, juvenile transport history, fallback, dam operations, and river environment.

c. Continue evaluation of the effects of temporary straying behavior (e.g., into cooler tributary streams) on escapement of summer and fall chinook salmon and steelhead in response to warm water conditions in summer.

6. Evaluate use of existing telemetry information for known-source fish to develop methods to estimate straying rates for ESUs (or ESU surrogates) in years without radiotelemetry (ADS-00-4).

7. Assess the effects of passage through the Columbia-Snake hydrosystem on the survival and reproductive fitness of adult salmon and steelhead (ADS-00-13).

a. Complete summary of the relationship between hydrosystem migration history, energy use, and reproductive success of South Fork Salmon River Chinook salmon collected at Bonneville Dam and resampled on spawning grounds in 2002-2004.

b. Collect at Bonneville Dam the South Fork Salmon River Chinook salmon PIT-tagged as juveniles specifically for adult migration evaluations, gather morphometric and energy reserve data, monitor migrations, and resample adults on spawning grounds in 2005.

c. Assess 2005 migration histories, energetic status, response to river environment, and reproductive success of designated South Fork Salmon River Chinook salmon.

d. Continue PIT-tagging of juvenile salmon from the South Fork Salmon River (McCall Hatchery) and initiate tagging at an additional site(s) for future evaluations of spawning success.

8. Evaluate detection efficiencies of new vertical-slot PIT-tag detectors at the top of the Washington-shore ladder at Bonneville Dam.

9. Maintain and perform quality control on the existing web-based interface to radiotelemetry data and broaden its scope to include additional years of data.

C. Methods

The adult passage research outlined here is a collaborative effort between personnel from University of Idaho, Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU) and the NOAA Fisheries. Project leaders will be responsible for preparation and submission of project proposals and respective work plans. Primary objectives for 2005 involve analyses of previously collected data and reporting on final results. Both groups will participate in the analysis of data and preparation of final reports, data summaries, and review presentations. NOAA fisheries will continue to maintain databases of telemetry data developed during 1996-2004 field seasons. Limited numbers of fish will be radio-tagged to evaluate detection efficiencies of PIT tag detectors

to be installed at the top of the Washington-shore fishway at Bonneville Dam. For that objective, ICFWRU personnel will continue to secure research permits, tag fish, install, maintain, and download telemetry equipment, complete coding of telemetry records to define movements and behavior of radio-tagged fish and maintain databases in Moscow.

Protocols for field operations, downloading of data from receivers, and coding of the data will be similar to those developed in prior years.

For 2005, we propose to summarize previously-collected data to address several topics that potentially affect the probability for adult salmon and steelhead to successfully migrate to spawning areas and reproduce in the Columbia and Snake River basins. Specific summaries will include identifying rates and routes of fallback at dams; effects of spill and other operational variables on fallback and passage times; examining relationships between fallback, passage times, fishway use, survival, and reproductive success; effects of smolt migration and transport, rearing history, and river variables on homing and straying rates of adult fish; and analyses of model development and use of alternative methodologies (e.g., use of PIT tags) for future adult studies in the absence of radiotelemetry.

In 2002-2004, we collected Chinook salmon at Bonneville Dam and from spawning grounds in the Salmon River for proximate tissue analysis to develop a non-lethal measure of energy content and use. From those analyses we found that a combination of body metrics (length, weight, and two depth measures) was correlated with total lipid content ($r^2 > 0.8$). During 2005, South Fork Salmon River (SFSR) Chinook salmon PIT tagged during 2003 specifically for energetic and reproductive success evaluations will be returning. We propose to collect a sample of these fish at Bonneville Dam, gather morphometric and energy reserves data, and then monitor migrations and resample adults at Lower Granite Dam and on spawning grounds. Use of this designated group of fish will aid evaluation of relationships between migration history through the Federal hydrosystem, energy use, and reproductive success.

Studies and work planned for 2005 are listed by objective.

1. Summarize existing data (1996-2004) on fallback and effects of fallback on passage success for adult salmon and steelhead at lower Columbia River dams, in relation to environmental and operational conditions (ADS-00-1).

This objective relates to Reasonable and Prudent Alternative actions (RPAs) 60, 93, 111, 112, and 113 listed in Section 9.6.1 of the 'Hydrosystem' Biological Opinion released by NMFS, December 2000.

1a. Summarize fallback rates, routes, timing, and percent of fish that fall back at Bonneville, The Dalles and John Day dams in 1996-2004.

Relatively large numbers of adult salmon and steelhead fall back in some years. On average (1996-2001), 22% of radio-tagged spring–summer Chinook salmon, 15% of fall Chinook salmon, and 21% of steelhead fall back at least once during their passage through the Columbia River hydrosystem (Boggs et al. 2004a). Fallback rates at individual dams have typically been highest at Bonneville and The Dalles dams, and are higher in years with high discharge. In these earlier studies, we identified that adult salmon and steelhead fall back at dams through

spillways, powerhouses, navigational locks, juvenile bypass systems, and ice and trash sluiceways (Bjornn et al. 2000a, 2000b, 2000c; Boggs et al. 2004a, 2004b; Jepson et al. 2004). Fallback can result in lengthened passage times (Keefer et al. *in press*) and reduced hydrosystem escapements for adult salmonids from all runs (Keefer et al. *in review*). In addition, many fallback fish reascend fishways at dams, and multiple passages by individual fish result in inflated fish counts. Counts are used for many management objectives, and summaries of potential count biases are needed to assure decisions are made using the best available information.

In 2005, we propose to summarize in final reports, fallback percentages, rates, and routes, as well as count correction factors at lower Columbia River dams for all previous years' research (1996-2004). Such comprehensive summaries on where, when, and at what rate adult fish fall back are needed to better manage spill, flow and other operations (e.g., powerhouse priority at Bonneville Dam) at the lower Columbia River dams. Multi-year summaries will also be valuable for assessing the effects of fallback on specific populations, including ESUs. Statistical analyses will include inter- and intra-annual comparisons, tests for differences among species and between known-source stocks, as well as dam-specific and hydrosystem-wide comparisons for each category. All summaries will be developed in consultation with Corps and NOAA Fisheries Regional Office personnel.

1b. Summarize multi-year (1996-2004) relationships between fallback behavior and operational variables.

In previous years, intensive mobile tracking of radio-tagged fish in the Bonneville Dam forebay identified adult fallback routes and established a correlation between dam spill and fallback rates (Bjornn et al. 2001; Reischel and Bjornn 2003). Additional studies also found elevated fallback rates at The Dalles and John Day dams during high-flow and spill conditions (Bjornn et al. 2000b, 2000c, 2001). In response to these early results, dam spill tests were conducted in 2002 through 2004 to better determine effects of spill and flow priority (e.g., Powerhouse 1 versus Powerhouse 2 at Bonneville Dam) on fallback. In addition, antenna arrays were set up in the Bonneville Dam forebay and at selected fallback routes, including the new surface bypass, to more closely monitor passage and fallback behavior and routes (Boggs et al. *in review*). In 2005, we propose to integrate results from spill tests, route monitoring, and other broad operational and environmental measures at lower Columbia River dams, and to summarize their relationships with fallback behavior.

The goal of this research segment is to refine relationships between fallback rates and routes at dams and specific operational and environmental conditions. Using data from 1996-2004, we are developing logistic regression and time series regression models, and hazard analyses that will allow project managers to estimate fallback rates at lower Columbia River dams based on river conditions and project operations. We are investigating relationships at temporal scales ranging from hourly to annual intervals. Formats for model and analyses outputs (e.g. tabular, graphical, interactive display) will be evaluated for utility and ease of use at a variety of management levels.

1c. Summarize effects of fallback behaviors on hydrosystem escapement in 1996-2004.

Fallback at dams has been associated with lowered hydrosystem escapement by adult salmon

and steelhead, especially for Chinook salmon stocks that migrate during periods of high river flow and spill and fish that fall back via non-spillway routes in fall (Keefer et al. *in review*). From our estimates of hydrosystem escapement, fallback fish survive at lower rates than non-fallback fish, with average (1996-2002) decreases of 7% for spring–summer Chinook salmon, 20% for fall Chinook salmon, and 13% for steelhead after adjustment for harvest. These decreases represent an estimated 1 to 4% decrease in population-level hydrosystem escapement. In 2005, we propose to continue summaries of fate and escapement for radio-tagged fish, with particular emphasis on comparisons between fallback and non-fallback fish.

As part of Objective 1c, we will evaluate the escapement effects of single versus multiple fallback events, and we will also assess if fallback at individual dams or during specific times of the year differentially affect escapement rates. Chi-square analyses and likelihood ratio tests will be used to quantify statistical differences between groups of fish (e.g., fallback versus non-fallback fish, single versus multiple fallback fish, or groups of fish that fell back at specific sites or times of the year). If sample sizes permit, additional escapement evaluations based on operational and environmental data will be addressed using linear and logistic regression models.

Effects of fallback on reproductive success will be evaluated for South Fork Salmon River salmon used in the 2002-2004 energetic study, as sample sizes allow. We will make similar evaluations for the designated SFSR fish returning as adults in 2005 (see Objective 7).

1d. Report effects of fallback history on proportion of fish of known origin (PIT tags) that reach streams or hatcheries of origin.

Telemetry information collected in 2000-2004 included relatively large numbers of fish of known origin. We identified these fish from juvenile PIT tags and an automatic detector in the adult trap at Bonneville Dam. The known-source groups have provided a unique opportunity to evaluate fallback histories for specific stocks. In 2005 we propose to summarize fallback histories for known-source groups and to relate those histories to homing, straying and escapement rates. Analyses will be similar to those described for all fish in Objective 1c.

The largest known-source samples were of spring–summer Chinook salmon and steelhead collected as juveniles at Lower Granite Dam. These stocks were either transported (barged) or returned to the river as juveniles. Initial results from 2000-2002 indicate significantly higher adult fallback for transported groups. Analyses of juvenile transport/adult fallback relationships will continue in 2005 with the addition of data from 2003 and 2004 samples. Effects of transport on homing, straying, fallback, and survival will be examined using multiple logistic regression models that include all data (2000-2004) and data from individual years. Results of these evaluations, which are required in the 2000 NMFS Biological Opinion, will be important for interpreting the consequences of juvenile barging on adult fish

2. Summarize existing data (1996-2004) on behavior, passage times, and effects of passage times on passage success of adult salmon and steelhead at lower Columbia River dams in relation to environmental and operational conditions (ADS-00-1).

This objective relates to RPAs 116, 117, and 119 listed in Section 9.6.1 of the ‘Hydrosystem’

Biological Opinion released by NMFS, December 2000.

2a. Summarize passage times for adult salmon and steelhead at Bonneville, The Dalles, and John Day dams and evaluate environmental and operational factors associated with passage times from 1996-2004.

Dams represent physical obstacles to upstream migrating adult salmon and steelhead. Upon encountering these projects, fish must negotiate the tailrace area and locate fishway entrances amongst potentially confusing discharges from spill, turbines, and the navigational lock. Adult migrants must then voluntarily enter and ascend fishways to successfully pass the dam, and this activity must be repeated multiple times (more for fish that fall back at dams) for fish destined for upstream spawning areas. Although some fish will pass dams quickly (4 to 6 h), median passage times typically range from 0.5 to 1.5 d, and some fish require several days or weeks to successfully pass a single project (Keefer et al. *in press*). Factors that may contribute to longer passage times include river conditions such as extreme low or high temperatures and low visibility, and dam operations such as spill levels, tailwater elevations, and fluctuations in operations, such as power generation loads or power house priority (e.g., at Bonneville Dam).

In 2005, we propose to summarize passage times and fish behaviors at dams at multiple scales. On a broad scale, we will examine the variability in fish passage times between years, between dams and reservoirs, and over longer hydrosystem reaches. These summaries will be useful for understanding large-scale processes such as the slower migrations observed in high-discharge years, as well as the variability between sites and fish runs. On smaller scales, we will continue examining fish behavior at sites identified as potentially problematic for adult migrants. Specific areas that may contribute to passage delays within fishways are transition pools (Bjornn et al. 1998; Keefer et al. 2003b), count stations, PIT tag detectors, and the vertical-slot (flow control) sections at tops of fishways. Fish may also have difficulty locating fishway entrances during periods of high flow, spill or turbidity.

Summary reports will focus on individual projects, as fishway configurations, fish behaviors, and adult passage concerns vary among sites. For example, 55 to 60% of spring–summer Chinook salmon passed straight through transition pools at McNary and Ice Harbor dams in 1996, compared to 36% at Bonneville Dam and 20% at Lower Granite Dam (Keefer et al. 2003b). Almost twice as many Chinook salmon (all runs), steelhead and sockeye salmon exited transition pools into the tailrace at John Day Dam (43-87% exited) than exited transition pools at The Dalles Dam (22-51% exited) in 1997 and 1998 (Keefer et al. 2003a). At most dams, we have found that fish that pass directly through transition pool areas have significantly faster dam passage times than fish that return to the tailrace before passing dams (Bjornn et al. 1998; Keefer et al. 2003b). Factors that may impede fish passage through transition pools include: low velocities through transition pools relative to velocities at fishway entrances and in the ladders, non-uniform flow direction caused by water added to the fishway at diffuser grates, submergence of the first few weirs of the ladders when tailwater elevations are high, and discontinuities for temperature or light conditions. Time to pass dams for up to two-thirds of the fish could be reduced if passage through transition pools was more efficient and fewer fish exited fishways into the tailrace.

Structural modifications to fishways have the potential to reduce fishway exit rates. For example, preliminary experimental results at Lower Granite Dam (Naughton and Peery 2003)

indicate that transition pool weir modifications that increase velocities through weirs can reduce transition pool fallout and lower dam passage times for adult Chinook salmon and steelhead.

Count windows, which are covered, lit, and narrow passage points, may also create a discontinuity in conditions in fishways that may inhibit free movement of fish. Adult salmon and steelhead have been observed by fish counters to, at times, move upstream and then downstream or hold for extended periods of time at count windows. In addition, the fishway at Bonneville Dam transitions from overflow weirs to vertical-slotted weirs just upstream from the count window. Conditions in these areas of ladders may delay fish from moving upstream and out of the fish ladders. In 2005, we will summarize window passage and vertical-slotted weir evaluations using data collected in previous years at Bonneville and John Day dams.

For summaries included in Objective 2a we propose to use data collected from 1996-2004 (as available for each dam and passage question) to evaluate time spent by radio-tagged salmon and steelhead during each segment of their passage at lower Columbia River dams, to identify areas associated with passage difficulties, and to relate passage times to river and operational conditions. We will also assess the factors that contribute to successful adult passage at hydrosystem dams and identify where modifications may be made to improve passage. Analyses to be used will include regression and multiple regression for large scale (among year) analyses, and multivariate (principal components analysis, multiple analysis of variance [MANOVA], etc.) analyses for smaller-scale (within year and season) relationships. Analysis of variance (ANOVA) and other appropriate statistical tests will be used to compare passage times in cases where experimental treatments occurred, such as the modified weir test at Lower Granite Dam, spill tests, and orifice gate closures.

2b. Summarize effects of passage times and behaviors at dams and in reservoirs on hydrosystem escapement from 1996-2004.

Ultimately, passage time concerns among managers stem from the question of whether or not cumulative 'delay' experienced by fish during their passage through the hydrosystem negatively affects the ability of adult migrants to reach spawning areas and successfully reproduce. In 2005, we will assess effects of the amount and types of passage delays on adult salmon escapement through the hydrosystem. We will determine if passage times through specific migration sections (e.g. through dam transition pools, past individual or multiple dams, through reservoirs) affects the probability of adult salmon and steelhead reaching spawning areas. We will also examine whether specific sources of delay (fallback, fishway fallout, temperature blocks, etc.) or timing of delays (early versus late in a migration) affect the probability for individual fish to escape past Lower Granite Dam (or other reference location) and reach upstream spawning areas. Existing data (1996-2004) will be used to model effects of passage time and delay on system-wide survival rates, and stock-specific summaries for relevant ESU stocks (or ESU surrogates) will be compiled using known-source fish collected from 2000-2004. Primary analyses will use time-to-event (hazard) techniques to equate probability of migration success to passage times and specific behaviors. Additional statistical methods will include univariate and multiple logistic regression, chi-square analyses, and linear regression.

2c. Report effects on passage of adult salmon and steelhead of spill flow patterns and deflectors at Bonneville and John Day dams, the new spill wall at The Dalles Dam, the modified south ladder at John Day Dam, and orifice gate closures at John Day Dam.

In recent years, several structural and operational changes have been made at lower Columbia River dams. These include spill tests, new construction (spill deflectors, spill wall), and closure of orifice gate entrances. Modified spill operations and installation of spill deflectors at Bonneville Dam have created both attractive flows for adult migrants seeking fishway entrances and turbulent conditions (at some spill levels) that may interfere with fishway entrance use. Preliminary results from spill tests at Bonneville and The Dalles dams indicate that adult salmonids modify passage behaviors in response to the magnitude and distribution of spill, and that avoidance of turbulent conditions can substantially lengthen dam passage times. In previous studies, effects on adult fish passage from closing orifice gates were limited (e.g., at Priest Rapid Dam, Bjornn et al. 1997). Orifice gate closures at Bonneville, The Dalles and John Day dams have not yet been fully evaluated. In 2005, we propose to complete evaluations of spill tests, spill deflector and spill wall installations, and orifice gate closures. In all cases, fish passage times and patterns of fishway use will be evaluated in terms of river and operational conditions. Where appropriate, passage indices will be compared between pre- and post construction phases. Statistical methods will be similar to those described in Objective 2a.

3. Develop ESU-based models and evaluate alternative methodologies (e.g., PIT tag technology) that can be used to estimate adult fallback and passage behaviors without radiotelemetry (ADS-00-1).

This objective relates to RPAs 60, 93, 111, 112, 113, 116, 117, and 119 listed in Section 9.6.1 of the 'Hydrosystem' Biological Opinion released by NMFS, December 2000.

During 2000-2004, many of our radiotelemetry research objectives relied upon collection and monitoring of known-source fish. Data from these groups have provided valuable information on stock- and ESU-level differences in adult behavior, fallback, passage time, and survival metrics. Samples of previously PIT-tagged fish that could be used for these adult studies were highly dependent upon juvenile research objectives. For long-term monitoring and among-year comparisons of ESU-level populations, however, consistent availability of relevant ESU stocks (or their surrogates) will be necessary. Table 1 summarizes approximate numbers of juveniles PIT tagged from each ESU (including what we believe are appropriate surrogates) in 2003 and 2004 that will potentially return as adults during 2005 and 2006. Typical smolt-to-adult returns (SARs) for Snake River stocks have been less than 1% (Sandford and Smith 2002), suggesting that PIT-tagged adult returns for some ESUs in 2005 may be quite small, with larger numbers potentially returning in 2006.

Future adult salmon and steelhead studies may increasingly rely on monitoring strategies other than radiotelemetry, yet to date no reliable replacement has been developed. PIT-tag detection systems may be able to reproduce some adult passage metrics, but methodological refinements are needed before these systems can be used for broad monitoring purposes. Directly monitoring fallback events with the PIT system, for example, is not currently possible.

PIT-tag systems have three basic benefits over radiotelemetry: 1) lower individual tag cost, 2) stock-specific data can be collected if adequate numbers of juveniles were previously tagged, and 3) adult fish need not be handled if appropriate juvenile samples for the research question are available. Disadvantages of relying on PIT systems include: 1) limited detection ranges which limit possible detection locations and effectiveness, 2) relatively high costs for

infrastructure installation, and 3) low return rates by juvenile-tagged fish (e.g., attrition rates result in high tagging costs per individual returning adult fish). In 2005, we propose to examine costs and benefits of radiotelemetry versus PIT systems and we will attempt to reconcile the two monitoring approaches using modeling and PIT-radio data comparisons.

In 2005, we propose to develop recommendations for when and how PIT systems can best be used to replace or augment radiotelemetry studies. With input from managers, we will also identify potential ESU index stocks (also see Objective 4) that could be used for long-term monitoring objectives. Stock selections will likely differ based on research objectives. As examples, fallback disproportionately occurs for spring Chinook salmon stocks migrating when Columbia River discharge is high (Boggs et al. 2004a), passage times are typically much longer for steelhead stocks migrating when water temperatures peak in August than for those migrating in fall (Keefer et al. *in press*), and escapement varies significantly among species and stocks within species (Keefer et al. *in review*). Selection of individual stocks to represent ESUs may therefore oversimplify adult behavior, and we will clarify potential biases inherent in an index-based system as much as possible.

Table 1. Numbers of juvenile Chinook salmon and steelhead PIT tagged in 2003 and 2004, and the ESU with which fish are associated. Hatchery and wild groups combined. All data are approximate (based on data downloaded from PTAGIS in July, 2004).

ESU	Listing status	2003	2004
Upper Columbia Spring Chinook[a]	Endangered	800	320,100
Snake River Spring–Summer Chinook[b]	Threatened	276,800	663,200
Snake River Fall Chinook[c]	Threatened	71,300	150,700
Lower Columbia Chinook[d]	Threatened	*None*	*None*
Middle Columbia Spring Chinook[e]		18,700	64,000
Upper Columbia Summer–Fall Chinook[f]		213,100	227,100
Upper Columbia Steelhead[g]	Endangered	206,500	385,900
Snake River Steelhead[h]	Threatened	108,900h	113,500
Lower Columbia Steelhead[i]	Threatened	*None*	4,700
Middle Columbia Steelhead[j]	Threatened	19,600	104,000

[a] Wenatchee, Entiat, Methow
[b] Grande Ronde, Salmon, Imnaha, plus includes fish tagged in Clearwater, Snake River mainstem, at Snake River dams and all fish with 'unknown Chinook' designation collected in Snake
[c] Clearwater, Snake River dams, Snake River mainstem
[d] only Wind, Little White Salmon 'Tule' population pass Bonneville Dam from this ESU
[e] Klickitat, Deschutes, John Day, Yakima, Umatilla, Walla Walla
[f] upper Columbia dams
[g] Methow, Okanogan, Wenatchee
[h] all Snake River tributaries and dams
[i] only Wind, Hood populations pass Bonneville Dam from this ESU
[j] John Day, Umatilla, Walla Walla, Yakima, White Salmon (includes ~96,000 Ringold hatchery steelhead in 2004)

3a. Use radiotelemetry data for known-source fish (2000-2004) and for all radio-tagged fish (1996-2004) to develop predictive fallback models for lower Columbia River dams.

Alternative methods for predicting and measuring adult fallback at dams will be needed in

future years when radiotelemetry is not used. In 2005, we propose to continue development of fallback models using previously-collected (1996-2004) telemetry data and associated environmental and operational data for lower Columbia River dams. General models using all radio-tagged fish from all years will be compared to stock-specific models using known-source fish radio-tagged from 2000-2004. Known-source fallback models will be help determine variability among stocks, which will be useful when developing ESU-level fallback predictions for years without radiotelemetry. Fallback models will also aid managers making decisions regarding manipulation of flow and spill at dams, and help them evaluate likely effects of those decisions on adult fallback. Model types and parameterization will be derived from consultations with managers and from previous fallback studies (e.g., Bjornn et al. 2000a, 2000b, 2000c; Reischel and Bjornn 2003; Boggs et al. 2004b). Methods will focus on multivariate logistic regression techniques, relating fallback to species, season, river and operating conditions, at annual, seasonal, bi-weekly and daily temporal scales. Multiple grouping methods, such as day-blocks, fish-blocks, parameter bins, etc., will be evaluated to develop realistic and accurate models.

3b. Integrate existing radiotelemetry and PIT-tag databases to evaluate and truth methods for using PIT-tags and PIT-tag detectors as an alternative to radiotelemetry for monitoring adult salmonid behaviors and fallback at lower Columbia River dams.

In conjunction with telemetry-based fallback models, we propose to evaluate methods for using PIT-tag data collected at dams for estimating adult fallback metrics. Starting in 2000, some of the radio-tagged fish we monitored also had ISO 134 kHz PIT tags, either received as juveniles or implanted by ICFWRU when adults were collected. Starting in 2002, all adult salmon and steelhead we radio-tagged also contained ISO PIT tags. Passage and fallback estimates calculated using the telemetry datasets for 2000-2004 will be compared in 2005 to estimates using the PIT-tag-only detections. Because PIT-tag interrogators were not able to directly detect fallback events at dams, surrogate measures like reascension rates will need to be tested as an index of fallback relative to the radiotelemetry data. Resolution of additional fallback questions, such as tributary overshoot and fates of non-reascending fallback fish, are currently not possible using only PIT detections at dams. Recommendations regarding the potential of using PIT technology to monitor adult fallback will be further developed.

Although some dam-to-dam and multiple-dam passage times can be calculated with the current PIT detection array, potential surrogate measures for small scale measurement of passage times and behaviors (e.g., within transition pools or fishways) are currently limited. Development of PIT technology that can measure more complex adult fish behaviors, such as passage times past dams or through portions of fishways, will likely require installation of multiple detection sites at individual dams if PIT systems are to produce data comparable to the radiotelemetry datasets. We will examine the possibilities of using PIT technology for monitoring fish behaviors in fishways and calculating passage metrics at dams.

4. Identify index stocks (e.g., South Fork Salmon River) to PIT tag and index streams to monitor to estimate adult passage parameters (ADS-00-1 and ADS-00-13).

This objective relates to RPAs 107, 111, 112, 113, 114, 116, 117, 118, and 120 listed in Section 9.6.1 of the 'Hydrosystem' Biological Opinion released by NMFS, December 2000.

Salmon and steelhead sampled for radiotelemetry studies from 1996-2004 were mostly randomly-collected fish from runs at large. Starting in 2000, we intentionally selected for previously PIT-tagged fish within each run, and varying proportions of each annual sample were consequently of known origin. Studies using these known-source fish have greatly facilitated understanding of stock-specific fates and the composition of unaccounted for Chinook salmon and steelhead. For example, we have been able to assess impacts to ESU groups (or ESU surrogates) and to determine if upriver stocks have different fallback, harvest or unaccounted-for loss rates than lower river groups. Use of previously PIT-tagged fish has required cooperation of researchers throughout the basin, and samples have therefore been constricted by the extent and availability of fish tagged for other projects. As a result, radio-tagged samples in 2001-2004 included relatively small numbers of fish from some stocks; fish PIT-tagged at Snake and upper Columbia River dams have been well represented in samples, but most specific tributaries, hatcheries and some ESUs have not (for example, see distributions in Table 1).

Increasing emphasis on ESU-level decision making may warrant the use of index stocks for estimation of adult passage parameters in future years. Year-to-year comparisons using index stocks can be invaluable for validating results collected so far, for describing inter-annual and between-ESU variability, and for monitoring fish responses to operational or structural changes in the hydrosystem. To date, one index stock has been identified. A group of 20,000 summer Chinook salmon smolts were PIT tagged at McCall Hatchery for release into the South Fork Salmon River in 2003 and 2004 to provide a pool of returning known-source adults that were designated solely for adult studies during 2004-2006. We suggest that McCall Hatchery salmon should continue to be PIT-tagged for use as an index stock. We also propose to identify additional suitable index stocks that could be used to represent other Chinook salmon and steelhead ESUs in the basin. Other potential groups to PIT tag for future evaluations include Deschutes River steelhead (lower river stock), Clearwater River steelhead and spring Chinook salmon and Snake River fall Chinook salmon (components of Snake River ESUs), and mid- or upper Columbia River summer Chinook and steelhead stocks. We would compare adult passage parameters for these groups to parameters for a broader collection of PIT-tagged Snake River Chinook salmon stocks to confirm their suitability to be used as index populations.

5. Summarize existing data (2000-2004) on homing and straying of known-source (PIT-tagged) adult salmon and steelhead (ADS-00-4).

This objective relates to RPAs 48, 50, 107, 118, 167, and 191 listed in Section 9.6.1 of the 'Hydrosystem' Biological Opinion released by NMFS, December 2000.

5a. Summarize homing and incidence of straying by known-source radio-tagged salmon and steelhead from 2000-2004.

In 2005, we will summarize homing success, temporary wandering, permanent straying, and out-of-basin harvest rates for all known-source fish radio tagged from 2000-2004. Clarification of straying rates is important for adjusting PIT-based escapement estimates and for evaluating 2000 Biological Opinion survival goals. Upriver (Snake, upper Columbia Rivers) stocks that stray to non-natal tributaries are considered escapement losses from natal streams and will artificially inflate escapement estimates in non-natal populations. Accurate documentation of straying, wandering and homing rates for specific stocks is necessary to reliably evaluate escapement and recovery goals for EAS listed populations. Additional concerns regarding

straying include documenting harvest of listed stocks that temporarily stray into non-natal tributaries and possible swamping of small wild populations by straying hatchery stocks (e.g., Snake River hatchery steelhead that stray into the John Day River). Out-of-basin spawning by hatchery fish can directly harm local wild populations (e.g., Waples 1991; Chilcote 2003). Some wandering and straying, including temporary straying, is a natural behavior of adult salmon and steelhead in the Columbia River. In our 1996 and 1997 studies we found that 64-70% of radio-tagged steelhead and 12-16% of spring/summer Chinook salmon that passed Lower Granite Dam entered lower Columbia River tributaries during their upstream migration; high temporary straying rates were also recorded for radio-tagged steelhead and fall Chinook salmon in 1998 and 2000. In all of the above studies, almost all radio-tagged fish were of unknown-origin. As a result, we could not identify numbers that permanently strayed into non-natal streams, were harvested in non-natal streams, or that died before reaching spawning areas.

Preliminary results from the 2001-2002 studies using known-source fish show that homing and straying rates vary significantly between species and stocks. Straying rates for known-source radio-tagged fish in those years averaged about 1.9% for spring–summer Chinook salmon and 6.9% for steelhead. Some harvest also occurred in non-natal tributaries, particularly of Snake River and upper Columbia River steelhead stocks in lower Columbia River tributaries. Some of these fish may have been straying only temporarily when mainstem river temperatures were high. In 2005, we will assess data from 2000-2002 along with data from known-source fish collected in the 2003-2004 studies to summarize within- and between-year variability in straying and homing among different known-source stocks. The data will be related to environmental and operational data to determine what factors have the greatest influence on straying behavior. Straying effects on hydrosystem escapement estimates will also be assessed.

5b. Report stock-specific relationships between adult straying rates and rearing history, juvenile transport history, fallback, dam operations, and river environment.

Our preliminary summaries of homing and straying by known-source fish indicate that Chinook salmon and steelhead that had been transported as smolts fell back over dams as adults at significantly higher rates than fish that were not transported. Chinook salmon barged from Lower Granite Dam as juveniles strayed at rates about five times higher than non-barged salmon, and both transported Chinook salmon and steelhead had lower escapement between Bonneville and Lower Granite dams than did fish that had migrated in-river as smolts, although harvest rates were not related to transport history. Chapman et al. (1997) and Bugert et al. (1997) also presented evidence that salmonids transported as smolts can have lower homing success than smolts that migrated downstream in-river.

In 2005, we will continue analyses of the homing effects of smolt migration history for PIT-tagged Snake River stocks. We will further examine effects of rearing history (hatchery versus wild) on homing for all known-source groups. Full-migration histories, including adult fallback, passage times and behaviors at dams, and environmental and operational exposure will be analyzed in terms of adult homing and straying rates for all 2000-2004 known-source groups. Because homing and straying behaviors may be related to multiple factors, multivariate techniques will be used to identify and describe influential factors.

5c. Continue evaluation of the effects of temporary straying behavior (e.g., into cooler tributary streams) on escapement of summer and fall Chinook salmon and steelhead in

response to warm water conditions in summer.

Summer water temperatures in the lower Columbia River regularly exceed 20°C. Many salmon and steelhead seeking cooler water temporarily wander into non-natal tributaries until mainstem water conditions improve (Goniea 2002; Keefer et al. 2002). Temporary straying, or wandering behavior can concentrate large numbers of fish in the lower reaches of tributaries and in tributary plumes within reservoirs, and these concentrations are highly susceptible to fisheries. This is of particular concern for listed upriver stocks that temporarily enter lower Columbia River tributaries. There is some evidence that upriver steelhead that wander into lower Columbia River tributaries during summer may have a survival advantage over fish that did not move into tributaries (High 2002), while for fall chinook salmon the effect may be reversed (Goniea 2002). Survival patterns as related to wandering have been based on limited data, and further analysis is needed to establish clear relationships between wandering and straying behavior and escapement estimates.

In 2005, we propose to summarize radiotelemetry data (1996-2004), temperature data collected with radio-data storage transmitters (RDST) in 2000 and 2002, and data from temperature recorders deployed with radio-tagged fish in 2004 to further understand relationships between temperature exposures, the incidence of temporary straying, and escapement levels. Temperature archives from RDSTs and recorders will also be used to evaluate exposures at specific sites, such as in fishways where warm water conditions may be problematic (e.g., Peery and Bjornn 2003; Keefer et al. 2003b), and to determine how exposures relate to fish behaviors and survival rates. Use of RDSTs and temperature recorders, primarily in known-source fish, will enable comparisons among some stocks and ESUs, and provide information for evaluations of how temporary straying may affect reproductive success and energy use (see Objective 7). Temperature exposures for individual fish will be summarized using average and median body temperatures for different species, river segments (lower Columbia, lower Snake) and season. Degree days, using 20°C as an index value, will be used to categorize warm water exposure levels. Passage success and survival will be related to temperature histories using regression, MANOVA and time-to-event analyses.

6. **Evaluate use of existing telemetry information for known-source fish to develop methods to estimate straying rates for ESUs (or ESU surrogates) in years without radiotelemetry (ADS-00-4).**

This objective relates to RPAs 48, 50, 107, 118, and 191 listed in Section 9.6.1 of the 'Hydrosystem' Biological Opinion released by NMFS, December 2000.

Because straying can affect escapement and survival estimates required for Biological Opinion evaluations in 2005, 2007, and 2009, a method of calculating straying rates without radiotelemetry is needed. We propose to develop predictive straying models using known-source Chinook salmon and steelhead radio-tagged in 2000-2004. Models will include environmental parameters such as river discharge and temperature, operational criteria like spill, and migration histories which include fallback, passage behaviors and passage times. Models will initially include all known-source fish data for each species; more precise ESU-specific models will be developed separately. Because availability of known-source groups strongly favored Snake River and upper Columbia River stocks in 2000-2004, straying models for these ESUs will likely have the most predictive capabilities. Representation for lower and mid-

Columbia ESUs among the radio-tagged groups was relatively sparse, and so only qualitative summaries may be possible.

7. Assess the effects of passage through the Columbia-Snake hydrosystem on the survival and reproductive fitness of adult salmon and steelhead (ADS-00-13).

This objective relates to RPA 107 (survival and reproductive success, energy expenditure) and 118 (pre-spawning mortality) listed in Section 9.6.1 of the 'Hydrosystem' Biological Opinion released by NMFS, December 2000.

While we have found evidence for survival effects for adult salmonids due to some behavioral (e.g. fallback and straying) and environmental (e.g. flow and temperature) factors (see Objectives 1, 2, and 5), little is understood about how cumulative metabolic costs and physiological stress associated with dam passage affect migration and reproductive success. Stress, disease, or excessive energy expenditure at dams or in reservoirs due to unfavorable in-river conditions may have a delayed effect on adult migration success and reproductive fitness. The EPA has recommend that temperature exposures for adult migrant salmon and steelhead not exceed 20°C over seven days (EPA 2003), but guidelines were based on limited data regarding physiological effects of warm water temperatures on adult anadromous salmonids. This objective outlines studies to relate reproductive success to migration history, estimates of energetic condition and expenditures, and in-river conditions, including temperature exposure.

7a. Complete summary of the relationship between hydrosystem migration history, energy use, and reproductive success of South Fork Salmon River Chinook salmon collected at Bonneville Dam and resampled on spawning grounds in 2002-2004.

In previous years, hatchery summer Chinook salmon from the South Fork Salmon River were collected at Bonneville Dam and again on spawning grounds. Morphometric and proximate tissue analyses were conducted for fish at both sites. Initial results indicated that fish weight, length, and two depth measurements produced a significant correlation with body lipid content, and that these data could be used to evaluate energy reserves for individual fish at multiple stages of their spawning migration. In 2005, we propose to continue analyzing energetic and reproductive metrics for South Fork Salmon River fish in relation to their fallback (Objective 1), passage time (Objective 2), and straying (Objective 5) histories. Environmental exposure, including discharge and temperatures encountered during migration, will also be examined.

7b. Collect at Bonneville Dam the South Fork Salmon River Chinook salmon PIT-tagged as juveniles specifically for adult migration evaluations, gather morphometric and energy reserve data, monitor migrations, and resample adults on spawning grounds in 2005.

In 2003 and 2004, 20,000 summer Chinook salmon smolts each were PIT tagged at McCall Hatchery on the South Fork Salmon River (see Objective 4). These fish were earmarked specifically for use in adult studies, including energetic analyses. In 2005, we propose to collect the first group of returning adults from this pool of designated fish at Bonneville Dam. During 2004, procedures were established and tested to collect and make mophometric measurements on individual adult salmon at Bonneville Dam and in spawning areas of the South Fork Salmon River. Fish may also be re-sampled at Lower Granite Dam as a mid-migration point that would

delineate migration through most of the hydrosystem from upstream, primarily unimpounded, habitats. Fish will be first collected at Bonneville Dam using sort-by-code procedures whereby fish are identified by their PIT tag codes. Each fish will be weighed, and their length and two body depth measures recorded. These measurements will be used to estimate energy condition using relationships previously developed for his stock of fish. A temperature recorder will be externally mounted at the base of the dorsal fin using surgical sutures, similar to procedures developed in 2004. We propose to radio tag as many of these fish as possible with used or reconditioned radio transmitters and to monitor their upstream migrations through the hydrosystem and to aide relocating fish in spawning areas. Resampling of adults on spawning grounds will include tissue sampling, along with collection of morphometric, reproductive and spawning status data. We also propose to collect gamete quality indices for a sub-sample of the females that return to the hatchery, to include egg number, size and weight, hatching percent, and larval survival.

7c. Assess 2005 migration histories, energetic status, response to river environment, and reproductive success of designated South Fork Salmon River Chinook salmon.

All reproductive and energetic data collected for Objective 7b will be analyzed in relation to migration histories. Measures of reproductive success, energetic status, gamete quality, and the presence of egg and larval abnormalities will be related back to original fish condition, temperature exposures, fallback histories, passage times and passage behaviors during migration. These analyses should provide new insight into possible delayed effects of fish behaviors within the hydrosystem. They should also indicate the importance of initial energetic status upon Columbia River entry relative to in-river migration environments and fish behaviors.

7d. Continue PIT-tagging of juvenile salmon from the South Fork Salmon River (McCall Hatchery) and initiate tagging at an additional site(s) for future evaluations of spawning success.

Continued PIT-tagging of South Fork Salmon River Chinook salmon will be important for maintaining available fish for future adult studies and for between-year comparisons. Reliance on only one stock for reproductive analyses, however, will somewhat limit the possible extrapolation of results to other populations (i.e., with different migration demands) and species. Four potential Snake River populations for future studies include Lyons Ferry fall Chinook salmon (includes fish released from Snake River acclimation ponds), Rapid River Hatchery spring Chinook salmon, Lookingglass Hatchery spring-summer Chinook salmon (includes fish outplanted in the Imnaha and Grande Ronde drainages) and Dworshak steelhead. Each of these stocks is a potential surrogate for Snake River ESU populations. Minimum sample sizes would be approximately 50 returning adults from one or more of these hatchery stocks; actual numbers will depend on space available in hatcheries. Availability of stocks from other Columbia basin ESUs will depend on cooperation with additional agencies. Stock selection for this objective should be coordinated with selection of index stocks for monitoring adult passage parameters, as outlined in Objective 4.

8. Evaluate detection efficiencies of new vertical-slot PIT tag detectors at the tops of Washington-shore ladder at Bonneville Dam.

PIT-tag interrogators designed for detecting adult anadromous salmon at dams were first tested at Bonneville Dam during 2001 and 2002. The initial design used detectors placed in the submerged orifices of several consecutive weirs within the fishways. This placement was established based on the assumption that salmon predominately use the orifices to ascend fishways. However, it was later determined that large numbers of fish ascend fishways by passing over weirs through the overflow sections, precluding their detection at orifice-mounted PIT detectors (Downing and Prentice *in review*). This was most prevalent during fall when fishways densities were highest. Consequently, preliminary findings from initial PIT systems tested at Bonneville and McNary dams indicate fall Chinook and coho salmon had lower detections efficiencies at PIT sites than did other runs. Likewise density effects and speed at which fish ascend individual weirs may also have influenced detection efficiencies. For example, summer Chinook salmon pass dams and migrate at faster rates than spring Chinook salmon, which may explain differences in detection rates of these two groups.

Orifice placement of PIT detectors in the middle of fishways also hampered interpretation of data for certain some passage metrics, primarily which fish successfully passed the dam. As a result of these early findings, detectors placed closer to the tops of ladders and that can monitor the entire water column in vertical slot weirs are thought to provide a better opportunity to record the greatest percentage of adult PIT tagged fish and provide information more useful for management applications.

PIT detectors are planned to be installed at the vertical slot weirs at the top of the Washington-shore fishway, Bonneville Dam, during the winter of 2004-2005. We propose to evaluate the effectiveness of these new PIT systems using samples of adult salmon double tagged with PIT tags and radiotelemetry transmitters. Radio receivers and antennas will be placed upstream and downstream from the new PIT detection installations, as well as at other critical locations, to document fish behavior in and near fishways.

We propose to PIT- and radio-tag a sample of summer and fall Chinook salmon, steelhead and coho salmon at Bonneville Dam to evaluate detection efficiencies of the new PIT-tag installations in the Washington-shore fishway. Fish will be collected, tagged, and released into the ladder at the Adult Fish Facility (AFF) trap located adjacent to the Washington-shore fishway. Telemetry antennas will be placed upstream and downstream of the AFF and in the vicinity of the new PIT detectors to record individual fish movement patterns within the fishway. Because of the simplicity and concentration of the monitoring area (Washington-shore fishway), we believe the sample size needed for this evaluation will be relatively small. Target sample size is 100 fish from each group to be tested (400 fish total) so that each fish will represents 1% of the sample. The proposed schedule would be to tag summer Chinook salmon during June, steelhead during August and September, fall Chinook salmon from mid-August until the end of September, and coho salmon from late August until late September (Figure 1). Fish would be tagged 5 d per week at a rate of 2 to 4 fish per day, depending on species.

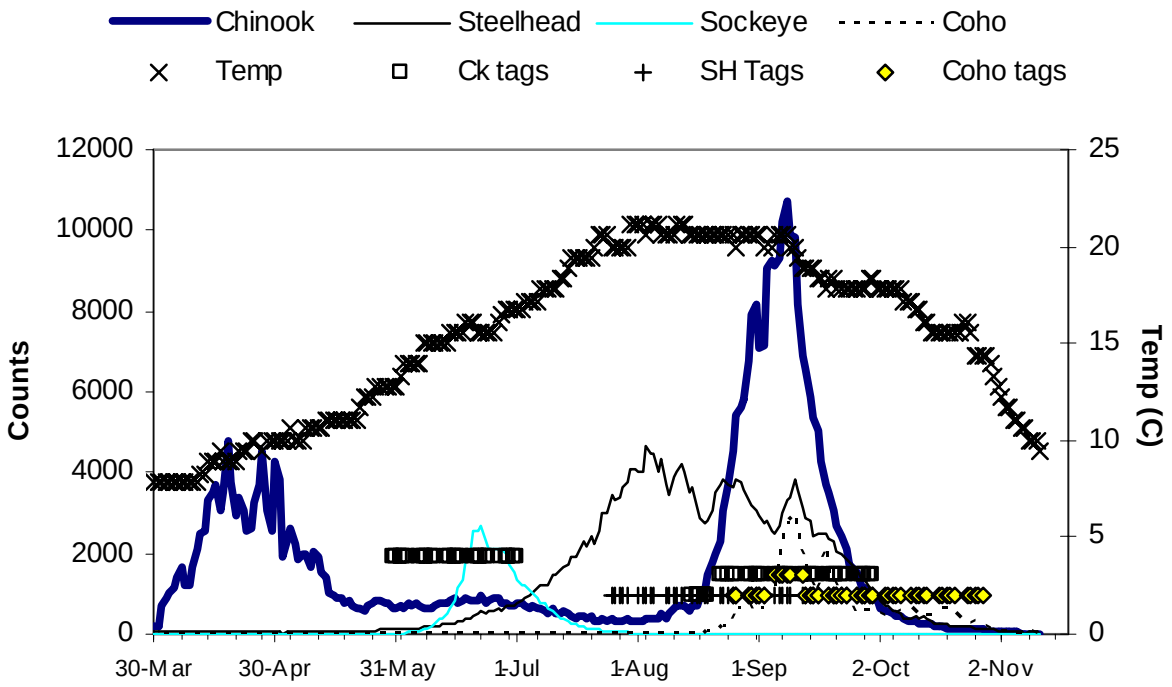

Figure 1. Average counts of salmon and steelhead at Bonneville Dam, water temperature and proposed numbers of fish to tag during 2005 study.

Because telemetry data tends to be non-normal, detections of double-tagged fish from the PIT and radiotelemetry systems will be compared using a signed-rank test (i.e. Wilcoxan; Steel et al. 1997). Data from 2005 will also be compared to previous years (2003-2004) to evaluate if detection efficiencies are improved. Passage detection efficiencies will be related to species/run, date, fish densities (based on fish counts), and air and water temperatures using multivariate techniques.

9. Maintain and perform quality control on the existing web-based interface to radiotelemetry data and broaden its scope to include additional years of data.

The creation of the web-based interface to the coded radiotelemetry records in 1996 and 1997 has been completed and is in the final stages of quality control. The page is expected to be available for access by late August, 2004. Based on initial public comment, revisions to the page may be necessary. Depending on the amount and extent of comments, we will prioritize updates to the web page and incorporate additional functionality as needed. In addition, we will communicate with CORPS personnel to determine an appropriate schedule for making additional years of radiotelemetry data publicly available through the web. Before each year is made available, strict quality control measures will be made to ensure data accuracy and completeness.

D. Facilities and Equipment

Computers and vehicles will be supplied by the researchers as needed on a rental basis. Radio telemetry equipment used in 2004 at Bonneville Dam will be used for the study in 2005. Installation of new antennas and repairs to existing antennas will be made as needed during the winter maintenance periods at Bonneville Dam and will be completed prior to commencement of tagging in summer of 2005.

E. Impacts of study on Corps projects and other activities

Division or district Corps personnel will be needed to provide technical review of research proposed for 2005.

Assistance from project personnel will be required as follows:

1. Provide electrical power supply at Bonneville Dam for electronics gear that will be used in the fishways and tailrace areas during 2005.
2. During the 2004-2005 fall and winter maintenance period we will inspect and repair antennas at each of the dams and will need access to fishways.
3. Provide access to the fish lab adjacent to the Washington-shore ladder at Bonneville Dam from late June through September to collect fish to be tagged.
4. Provide access to tailrace and fishways for regular downloading of radio receivers.

Biological Effects:

Tagging at Bonneville Dam in 2005 will follow similar procedures used in 2004; tagging will take place 5 d per week (M-F). Fish will be diverted from the fishway into the AFF, selected for tagging, anesthetized, fitted with transmitters, and released into a recovery area from which fish can voluntarily leave. Tagged fish will then be able to swim a short distance through the bypass ladder to re-join the Washington-shore ladder upstream from the AFF. During previous research radio-tagging adult salmon at Bonneville Dam, we have documented less than 0.09% mortality rate resulting from tagging operations. The indirect effect on salmon from tagging is a 3-4 hr delay for fish to recover from anesthesia and return to the main fishway at Bonneville Dam. During July and August, when temperatures can exceed 20ºC, we will add ice (river water) to the anesthetic and tagging tanks to keep temperatures near or below 20ºC. Tagging will be limited to 4 d per week when water temperatures exceed 21.1°C and tagging will be halted when water temperatures exceed 22.2ºC.

We will coordinate with other researchers using radio telemetry to avoid duplicate use of frequencies and codes in transmitters.

Key Personnel

Project planning, administration, final reporting:

Principle investigators, C. Peery, ICFWRU
B. Burke, NOAA Fisheries

Work plan preparation, protocols, computer programs, permits:

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B. Burke, M. Jepson
Analysis of data and preparation of report segments and presentations
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Technology Transfer

Information and analyses from this study will be provided regularly to managers via final reports and verbal presentations. Information that is appropriate will be published in technical journals. Special efforts will be made to provide information for managers as requested.

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